OPERATING AND MAINTENANCE MANUAL

DIGITAL CURRENT METER MODEL 1776

F.W. BELL

360670

F.W. Bell Digital Current Meter Instruction Manual

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8909.5TD Litho in USA UN-01-084

SIMPLIFIED OPERATING INSTRUCTIONS

1. Connect the 1776 Digital Current Meter to the appropriate power source. Connect the probe to the 1776. Turn the instrument on. A warm-up time of ½-hour is recommended.

2. Depress the CAL button and adjust the calibration potentiometer to obtain a 1000 reading. The instrument is now calibrated. Release the CAL button.

3. With the probe connected, but not clamped around an unknown current, adjust the COARSE and FINE zero controls to obtain a zero meter reading. The instrument is now ready to make measurements.

4. To make ac measurements, depress the ac/dc button. For dc measurements, the button should be in the released position. To make the measurement, simply clamp the probe around the unknown current and read the meter. Remember that the dc mode measures the dc component of the unknown current. The ac mode measures the ac component of the unknown current. The meter is average responding, calibrated to indicate the rms value of a pure sine wave function.

5. The PEAK reading button is used to read and hold the peak current present during a particular time span. Depress the PEAK button. The meter will display the highest *positive* peak current which flows through the conductor during the time the button is depressed. If there is more than one peak, the instrument will display the maximum absolute peak current. The reset clears the hold circuitry and prepares it for reading a new peak.

Please read this entire manual for complete instructions.

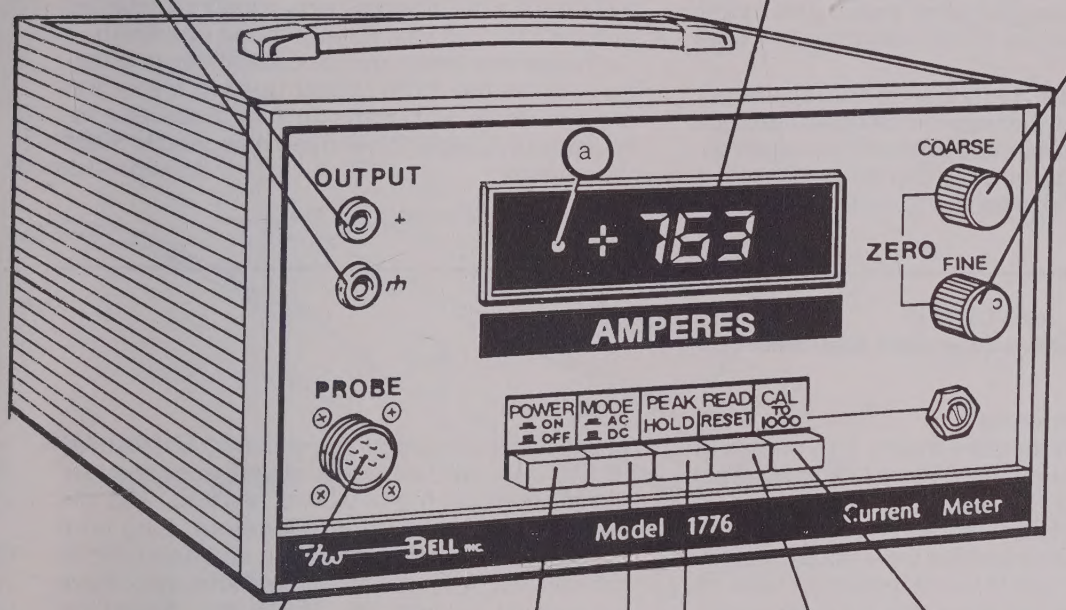
SPECIFICATIONS

CURRENT RANGES, dc and ac rms	0 to 10.00 A FS with probe P-100; overrange to 19.99 A. 0 to 100.0 A FS with probe P-101; overrange to 199.9 A. 0 to 1000 A FS with probe P-102; no overrange.
OVERALL ACCURACY, INCLUDING PROBES **dc and sinusoidal ac to 1000 Hz**	normal range: ±1.0% FS at 25°C. overrange: ±2.5% FS at 25°C.
peak reading	±2.0% FS.
FREQUENCY RESPONSE IN ac MODE **additional error 1000 Hz to 5000 Hz**	10 Hz to 5000 Hz. with P-100 (10 A) probe: +2.0% of reading, typical. with P-101 (100 A) probe: +3.0% of reading, typical. with P-102 (1000 A) probe: +3.0% of reading, typical.
PEAK READING	frequency response: 1000 Hz. fastest readable rise time: 250μs to full scale.
OUTPUT VOLTAGE	in dc mode: ±1.0V for full scale indication. in ac mode: 1.0 V rms for full scale indication of sinusoidal current. in peak hold mode: +1.0 V hold for full scale peak hold indication.
READOUT	digital, 3½ digits.
PROBE ISOLATION CAPABILITY	600 V dc or ac peak.
POWER REQUIREMENTS	115/230 V ac, 50/60 Hz and internal rechargeable Nicad batteries with built-in trickle charge circuitry (voltage selection is made at the factory) 15 W.
SIZE	5½" high, 10" wide, 10" deep (140 mm x 254 mm x 254 mm).
WEIGHT	net 10 lbs. (4.5 kg), shipping 13 lbs. (5.9 kg)
OPERATING TEMPERATURE RANGE	−10°C to +50°C.
SPECIAL FEATURES	All probes can be calibrated using the internal calibration feature of any 1776. The P-100 (10A) and P-101 (100A) probes have 100% overrange capability with slightly reduced accuracy.

OUTPUT
±1 volt for full scale indication on dc, 1 volt rms for full scale indication on ac.

DIGITAL READOUT
This 3½ digit display shows the current measured. Polarity of dc currents is also indicated.

ZERO
Coarse and *fine* zero controls, zero the instrument reading.



(a) BATTERY INDICATOR
This indicator lights when the internal battery charge level drops to a point where accurate measurements are no longer possible. The 1776 should be operated on the line or recharged for later use when this lights.

PROBE CONNECTOR
One of three available probes can be connected here. The instrument automatically ranges to the appropriate probe when it is connected.

ON/OFF SWITCH
Depress this button to turn the instrument on.

AC-DC FUNCTION
When depressed, this switch permits ac current measurements. When released, the instrument is in dc mode.

PEAK READ
When the HOLD button is depressed, the 1776 will read and hold the highest positive peak current indefinitely until the RESET button is used to clear the instrument.

RESET
This button clears the peak reading indication and prepares the instrument for the next peak reading.

CALIBRATE
Depress this button to calibrate the 1776 to a full scale reading of 1000.

DESCRIPTION

The Bell model 1776 Digital Current Meter provides a revolution in metrology via its ability to accurately measure ac, dc, (and ac on dc) current with a non-contact clamp-on probe. No longer is it necessary to break the circuit to make a current measurement. This time saving feature is extremely helpful in the troubleshooting, repair, and design fields. Now it's possible to obtain current measurements more easily and safely than voltage measurements with isolation from the bus.

The Bell model 1776 Digital Current Meter introduces virtually no resistance on dc readings and extremely small impedance on ac readings. In this way, measurements can be made with a minimum of disturbance in the measured circuit, a tremendous advantage in making those difficult transient response tests.

The unique circuit design coupled with the digital readout provides a wide dynamic range of measurements with excellent resolution. For example, readings can be made down to 10 milliamperes while the upper end limit is 1000 amps dc or rms ac.* The 1776 is designed for portable operation with internal rechargeable batteries and for 115/230 Vac, 50-60 Hz line operation.

These and other unique capabilities and features make the 1776 Digital Current Meter the most versatile and useful current measuring instrument available. It has been designed to meet your needs.

*A dynamic range of 100,000 to 1.

SECTION III
Installation and Pre-Operation Adjustments

III-1
(a) Power Requirements

The Model 1776 operates from a 115 volt ac or 230 volt ac line at 50 or 60 Hz. Each instrument is pre-adjusted at the factory to the 115 or 230 volt operation levels. Check the rating of your instrument to make sure that the voltages match. Instruments rated at 115 volt operation have no identifying power tag while the 230 volt operation instruments have a tag identifying them as 230 volts. All units accept 50 or 60 Hz power.

Internal rechargeable NICAD batteries provide true portable operation. A built-in trickle charger maintains the NICAD batteries at full charge while the instrument is attached to the ac line and is "on". When attached to the line and "off", the instrument recharges the batteries at a full recharge. For example, after eight hours of portable operation the 1776 should be attached to the ac line in the "off" position for sixteen hours. The instrument draws 15 watts of power.

(b) Pre-Operation:

Attach the probe connector to the front panel. Make sure the clamp ring is screwed down firmly. Turn the power switch on. For best performance, allow 30 minutes of warm-up before making measurements or calibrating the instrument.

III-2 CALIBRATION PROCEDURE
(a) General:

The calibration procedure should be performed before the instrument is used for current measurements. It should also be performed whenever probes are changed. Allow sufficient time for warm-up stability before calibrating.

(b) Calibration Against Internal CAL Signal:

Calibration against the internal CAL signal is a simple process which normally will provide the best possible accuracy. The accuracy and stability of the internal calibration signal is dependent upon precision high-stability resistors and the initial factory calibration. Therefore, long-term accuracy and high stability is a characteristic of this method. After the instrument and probe have warmed up, depress the CAL button. Adjust the CAL screwdriver adjustment to obtain a 1000 digital meter reading. The instrument is now calibrated. Release the CAL button before zeroing the meter.

III-3 Probe and Instrument Zeroing:

(a) After calibration, the probe and instrument should be zeroed. Allow the probe to be closed with no current flow through the aperture. This is best achieved by having the probe aperture free of any conductors. Adjust the COARSE then FINE zero controls on the front panel of the 1776 to achieve a zero meter indication. The instrument is now prepared to make measurements.

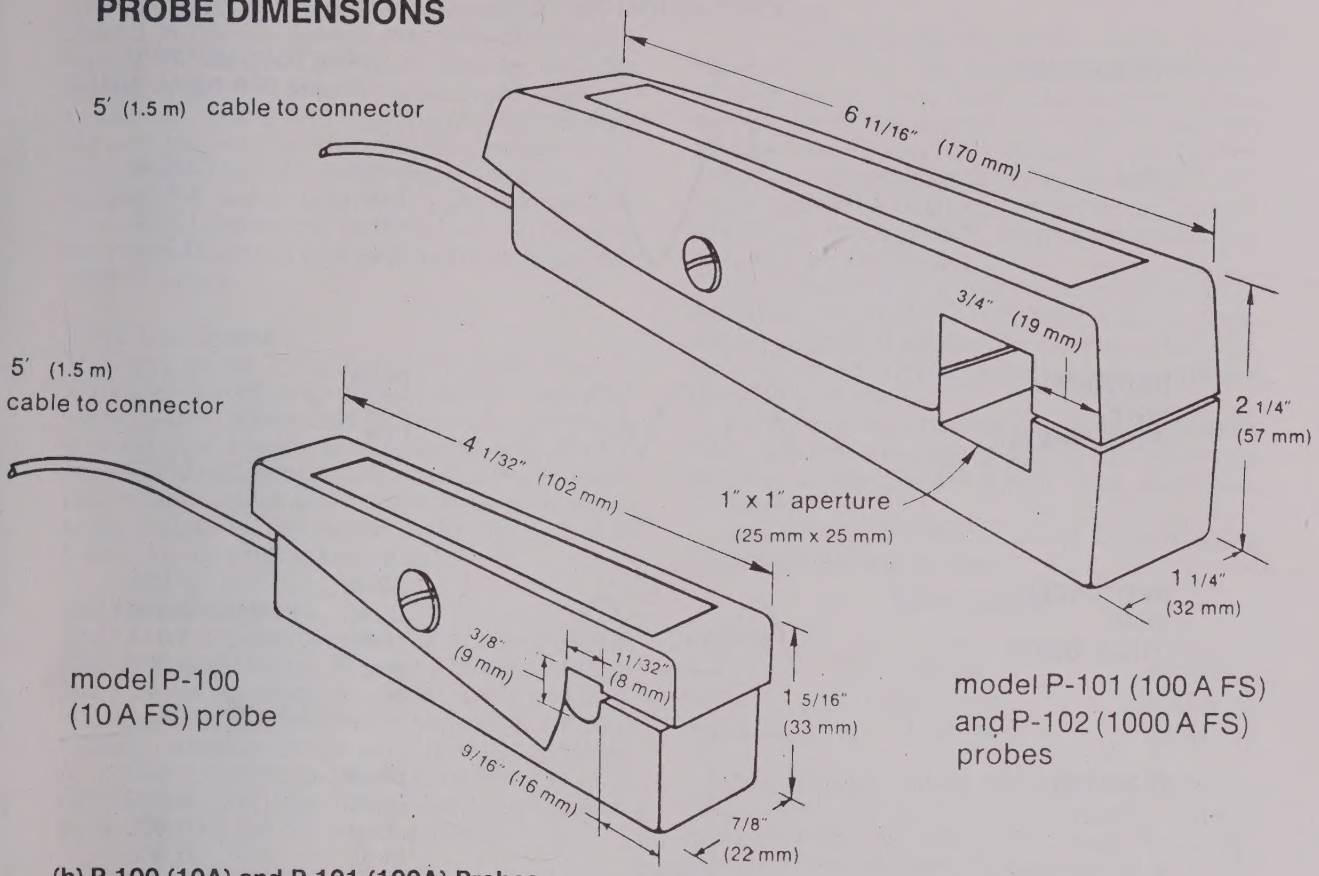
SECTION IV
Operating Instructions

IV-1 Probes
(a) General:

There are three basic probes for the model 1776 Digital Current Meter. These are clamp-on handheld probes designed to be opened and clamped around the conductor with one hand. For accurate readings, the probe must close completely around the conductor. The instrument range is set by the model of probe selected. See the chart below.

model	range, A
P-100	10.00
P-101	100.0
P-102	1000.0

PROBE DIMENSIONS



(b) P-100 (10A) and P-101 (100A) Probes

The 10 and 100 ampere probes are ruggedly designed to clamp around conductors to provide a current measurement. The probes are sturdy and will withstand heavy use. The 10 and 100 ampere probes are conservatively rated so they may be used for a two-times overrange with a slight reduction in accuracy. The reduction is an additional 1.5% of full scale accuracy. This means that a reading with a 10 ampere probe of 10 amperes has an uncertainty of 1% of full scale which would be .1 ampere. If the probe is used to make a reading of 19.99 amperes, the uncertainty is 2.5% of full scale (full scale equals 10 amperes). This is a total of .25 amperes.

(c) P-102 (1000A) Probe

The 1000 ampere probe has been designed to be hand-held and easily used. As a result of weight saving, the probe does not have a two-times overranging capability that the lower current probes possess. Considerable error may be experienced if the probe is used above 1000 amperes. The 1000 ampere probe is also very durable and will stand heavy use.

SECTION IV-2
Measurement Procedure

(a) General

The model 1776 is ready for operation at the conclusion of the pre-operational adjustments.

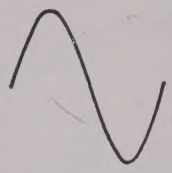
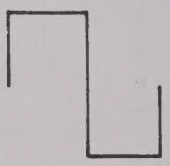
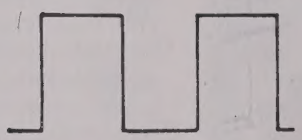
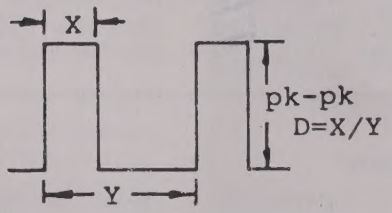
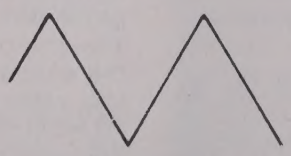
(b) dc Measurements

The ac/dc function switch should be in the dc position. Clamp the probe around the conductor of the unknown current. The current magnitude will appear on the digital panel meter. In addition, a voltage proportional to the current is available at the front panel output terminals. If the current is out of the range of the probe in use (see overrange section), disconnect the probe and connect the appropriate probe for the measurement. Changing probes requires a calibration and zeroing procedure before measurements can be made.

(c) ac Current Measurement

Depress the ac/dc function switch. Clamp the probe around the current carrying conductor. The unknown current value will be displayed on the digital readout. This value represents the rms value of the sinusoidal wave shape from 10 Hz to 5kHz. If the measured current is out of the range of the probe in use, change the probe and repeat the pre-operational adjustments. If the measured wave form is not a sinusoid, use the following chart to make the measurements. Multiply the meter reading by the appropriate form factor number. The 1776 is average responding, calibrated to indicate the rms value of a pure sine wave function.

ac CONVERSION FACTORS

WAVEFORM		FACTOR (MULTIPLY BY METER READING)	
SINE		pk-pk 0-pk rms avg	2.828 1.414 1.000 0.900
RECTIFIED SINE (FULL WAVE)		pk-pk 0-pk rms avg	1.414 1.414 1.000 0.900
RECTIFIED SINE (HALF WAVE)		pk-pk 0-pk rms avg	2.828 2.828 1.414 0.900
SQUARE		pk-pk 0-pk rms avg	1.800 0.900 0.900 0.900
RECTIFIED SQUARE		pk-pk 0-pk rms avg	1.800 1.800 1.272 0.900
RECTANGULAR PULSE		pk-pk 0-pk rms avg	0.9/D 0.9/D 0.9/D½ 0.9D
TRIANGLE AND SAWTOOTH		pk-pk 0-pk rms avg	3.600 1.800 1.038 0.900

(d) Peak Read and Hold Measurements
Clamp the probe around the current-carrying conductor. Depress the peak reading function switch. The front panel digital meter will immediately register and hold the highest *positive* current present from the time the measurement was initiated to the present instant in time. Any subsequent higher peak will cause the reading to increase and hold at the new level. To prepare the instrument for a new peak reading, press the RESET button.

(e) Voltage Output
The jacks on the instrument front panel provide a voltage output proportional to the measured current. This can be used for observing the measured current wave form on an oscilloscope or for any other measurement purpose. On the dc scale, the voltage output is a ±1 volt analog for a full scale indication. On the ac scale, the output is 1 volt rms for a full scale indication.

(f) Battery Operation
The 1776 is capable of continuous battery operation up to eight hours. When the battery voltage drops below an acceptable level, a warning light will appear at the left side of the meter display. Battery operation at this point is not suggested, as the instrument accuracy may be reduced. Accurate operation may immediately be obtained by connecting the 1776 to the ac line.

The batteries are being charged any time the instrument is on the ac line. If the current meter is in use, the batteries are being trickle-charged to maintain a full charge. When the instrument is in the "off" mode, the batteries are in a maximum charging condition. Two hours of full charging for every one hour of portable operation should maintain the batteries at a fully charged condition.

(g) Display Overrange
If the digital current meter is used at a current level greater than *two times* the probe current rating, except for the P-102, 1000 A probe, the digital display will indicate this as an overrange condition. The three least significant digits will blank, leaving the decimal point, a digital "one" and a polarity sign. To obtain a reading at this new level, the probe will have to be exchanged for a probe of the proper rated value.

(h) Frequency and Current Level Limits
Clamping a probe for the 1776 Digital Current Meter around a current conductor in which there is a signal which exceeds the ampere•frequency products stated below may be damaging to both the instrument and the probe. This can happen when the 1776 is in either the dc or ac mode of operation.

Safe Limits on the Use of the Probes: When the model P-101, 100 A probe is used with the 1776 in the dc mode, the ac component of the current being measured must not exceed an ampere (rms)•frequency product of 1100 A•kHz. When the instrument is in the ac mode, the P-101 probe cannot be used to measure an ac current which has an ampere (rms)•frequency product greater than 750 A•kHz.

With the 1776 in either the ac or dc mode of operation, the model P-102, 1000 A probe, must not be used to measure any current which has an ampere (rms)•frequency product greater than 1200 A•kHz.

Current spikes or pulses should be converted to an ampere•frequency rating to determine whether or not they fall within these safe limits of operation.

The P-100, 10 A probe, is not subject to the limitations defined above.

SAFE LIMITS

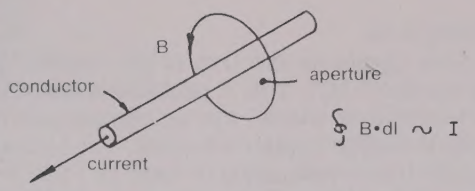
PROBE	ac MODE	dc MODE
P-102	1200A•kHz	1200A•kHz
P-101	750A•kHz	1100A•kHz

Potential High Voltage Damage: The magnetic fields associated with ac or transient currents generate a voltage in the 1776 probes. For waveshapes which exceed the specified safe limits, this voltage becomes high enough to overload the protective devices in the instrument and do extensive damage to the circuitry.

Potential Thermal Damage: If the measured current is greater than the ampere•frequency limits, the temperature of the core in the probe could rise above the designed thermal limit. This increase in temperature will adversely affect the sensing element in the probe. Depending on the circumstances, the damage incurred by the probe may be permanent.

SECTION VI
Theory of Operation

A magnetic field is associated with every current flow. The strength of the magnetic field is related to the magnitude of the current. Ampere's Law states that the line integral of magnetic field (this is an integral around a closed path) is proportional to the net current flow through the line aperture. The Bell Model 1776 Digital Current Meter operates on the principle of Ampere's Law.



The Model 1776 probe consists of a magnetic core and Hall generator. The core serves to concentrate the magnetic field surrounding the unknown current. In addition, the core approximates the line integral of magnetic field. The Hall generator, in a gap in the core, senses this concentrated, integrated magnetic field and provides a voltage output which is proportional to the current flowing through the core aperture. This voltage is delivered to the circuitry of the 1776.

This signal is amplified and conditioned to provide the various features and outputs of the digital current meter. Conductors external to the current probe normally will not effect the reading. The Hall generator is a high quality semi-conductor manufactured by F.W. Bell. Hall generators operate on the basis of the Hall effect. This effect occurs when a current flows through a conductor in the presence of a magnetic field. A voltage will be developed that is proportional to the current magnitude multiplied by the external field magnitude. In this way a voltage proportional to magnetic field is derived.

MAINTENANCE FOR MODEL 1776 CURRENT METER

1. INTRODUCTION

This section contains the necessary instructions and diagrams for maintaining the Model 1776 Digital Current Meter. In addition to the schematic diagram, a block diagram showing typical voltage levels is provided to aid in troubleshooting. Repair and adjustment of the instrument should be attempted in the field only where adequate test equipment and qualified personnel are available. Refer to the warranty page for the procedure to be followed should factory repair service be required. Caution: CMOS. Proper handling procedures must be used.

2. TEST EQUIPMENT

Voltmeter—Fluke 8000A or equivalent
Oscilloscope—Tektronix 503 or equivalent

3. COVER REMOVAL

Caution—Always disconnect the power cord from the power line when removing or replacing the cover. To remove the cover, remove the two screws on the rear and one screw from the front panel of the unit.

4. PERFORMANCE TEST

A. Preliminary

1. Make sure the power cord is properly connected and fully seated in the receptical.
2. Check the fuse for burn-out. Correct fuse size is ⅛ amp 3AG slow-blow for 110 Volt operation; 1/16 amp 3 AG slow-blow for 220 Volt operation.
3. Check the battery connections on the PC board and at the batteries.
4. Check for damage to the probe, cable, connector contacts, cores, etc.

B. Calibration Check

1. Plug the probe securely into the front panel.
2. Push the CAL button in; the meter should read near 1000.
3. Using the CAL control, a meter reading of 1000 should be obtainable with approximately 20 counts on each side of 1000.
4. Voltage at the output jacks should be 1 Volt dc for a full scale (1000) meter reading ±2 counts.

C. Zero Test

1. Release the CAL button and return to the dc mode of operation. Adjust the zero controls to obtain a zero meter reading.
2. A total range of approximately −700 to +700 counts typical should be obtainable.

D. Peak Read Test

1. With the ac/dc switch out (instrument in the dc mode), use the zero controls to adjust a plus (+) 010 counts on the meter.
2. Push in the Peak hold button and reset the Peak Detector Circuit by temporarily depressing the Peak Reset Button. The meter should then read 010 counts ± one digit.
3. While holding the Peak Reset Button in, the meter should read 000 ± one count.
4. Release the Peak Reset and Hold Buttons (return to the dc mode of operation) and use the Zero Controls to set plus (+) 700 counts on the meter.
5. Push in the Peak Hold Button and reset the Peak Detector by temporarily depressing the Peak Reset Button. The meter should then read 700 ± one count.

5. ADJUSTMENT AND ALIGNMENT PROCEDURE

A. Digital Voltmeter (DVM) Adjustment

1. Disconnect probe from the 1776 Digital Current Meter.
2. Connect an external voltmeter to the output jacks on the front panel of the 1776.
3. Using the Zero Controls on the front panel of the 1776, obtain a zero reading on the external voltmeter.
4. Depress ac/dc switch. The digital voltmeter display should read zero; if not, adjust the ac null pot (R227) and then release ac/dc switch.
5. Temporarily connect pin P-114 to terminal P-20S of the meter board (bottom terminal) with a clip lead.

6. In the dc mode, adjust front panel Zero Controls R226 for a reading of 700 on the 1776's digital voltmeter display.
7. Depress ac/dc switch and adjust ac CAL control for a reading of 778 on the 1776's digital voltmeter display.
8. Remove the clip lead from pin P-114 and terminal P-20S of the meter board.
9. Re-zero the 1776's digital voltmeter display using the front panel controls.
10. Connect a probe to the 1776.
11. Depress the CAL button and use the CAL control to obtain a reading of 1.000 volts on external voltmeter.
12. Adjust dc CAL control to obtain a reading of 1.000 on the 1776's digital voltmeter display.

B. Peak and Hold Calibration

1. In the dc mode of operation, zero the 1776 instrument.
2. Depress the Hold Button.
3. While holding in the Reset Button, adjust R137 (internal zero adjustment) for a flashing plus sign (+) and a reading of 000 on the 1776's digital voltmeter display.
4. Release the Reset and Hold Buttons. In the dc mode, use the zero controls to set a reading of +010 on the 1776's digital voltmeter display.
5. Depress the Peak Hold Button. Push in and release the Peak Reset Button and adjust R138 (low level Peak CAL) for a reading of +009.
6. Release the Peak Hold Button. In the dc mode, use the zero controls to set a positive (+) 700 on the 1776's display.
7. Depress the Peak Hold Button. Push and release the Peak Reset Button and adjust R136 (high level Peak CAL) for a reading of 700 one count.
8. Release the Peak Hold Button.

Note: Low and high CAL adjustment (steps 5 and 7) must be approached from a lower level than the desired setting.

C. Amplifier Adjustments

1. Disconnect the probe; disconnect the blue/black and green/black leads from terminals P-128 and P-125.
2. Connect terminals P-103 and P-104 to each other.
3. Connect a 100 ohm ±20% resistor across pins P-101 and P-107.
4. Connect a 100 ohm ±20% resistor across pins P-101 and P-102.
5. Connect the ground lead of an external voltmeter to pin P-101 and the input to pin P-118.
6. Using a clip lead, connect the two shorted terminals P-103 and P-104 to pin P-101. Adjust R106 (offset null) for a reading of 0.000 Volt ±0.5 millivolt on the external voltmeter.
7. Remove the lead connected to pin P-101 in step 6 and connect it to pin P-102. Adjust R105 (Common Mode Rejection) for a reading of 0.000 Volts ±1 millivolt on the external voltmeter.
8. Remove the two 100 ohm resistors, clip lead, and short. Re-connect the blue/black lead to pin P-128 and the green/black lead to pin P-125 and check the operation of the 1776's zero controls.

1776 PARTS LIST
Abbreviations

Cer	Ceramic	MYL	Mylar
Comp	Composition	OP AMP	Operational Amplifier
DVM	Digital Volt Meter	Ω	ohm
Elect or ELE	Electrolytic	p	Pico or 10^{-12}
F	Farad	Reg	Voltage Regulator
FET	Field Effect Transistor	Seg	Segment
FOP	Factory selected for optimum performance	T	Tantalum
		TG	Transmission Gate
IC	Integrated Circuit	μ	Micro or 10^{-6}
k	Kilo or 10^3	V	Working Volts
LED	Light Emitting Diode	Var	Variable
M	Meg or 10^6	W	Watt
MF	Metal Film	WW	Wire Wound
Mini DIP	8 pin, dual in-line package		

BASE PRINTED CIRCUIT BOARD

Schematic Ref	Value	Specifications			F.W. Bell Item No.
R100	6.8 k Ω	5%	1/2 W	Comp	313200
R101	10 k Ω	1%	1/4 W	MF	316350
R102	10 k Ω	1%	1/4 W	MF	316350
R103	30.1 k Ω	1%	1/4 W	MF	316350
R104	29.4 k Ω	1%	1/4 W	MF	316529
R105	1 k Ω		Cer	Var	322044
R106	20 k Ω		Cer	Var	322047
R107	200 Ω	1%	1/4 W	MF	315840
R108	4.7 M Ω	5%	1/4 W	Comp	312440
R109	49.9 k Ω	1%	1/4 W	MF	316579
R110	4.87 k Ω	0.1%	1/4 W	MF	315311
R111	4.32Ω	0.1%	1/10 W	WW	318375
R113	121Ω-127Ω	1%	1/4 W	MF	FOP
R114	20 Ω	0.1%	1/2 W	Comp	312600
R115	5.11 k Ω	0.1%	1/4 W	MF	315315
R116	10 k Ω	5%	1/2 W	Comp	313240
R117	10 k Ω	5%	1/2 W	Comp	313240
R118	10 k Ω	5%	1/2 W	Comp	313240
R119	10 k Ω	5%	1/2 W	Comp	313240
R120	10 k Ω	5%	1/2 W	Comp	313240
R121	1 M Ω	5%	1/2 W	Comp	313650
R122	1 k Ω	5%	1/2 W	Comp	313000
R123	4.99 k Ω	1%	1/4 W	MF	316240
R124	10 k Ω	1%	1/4 W	MF	316350
R125	20 Ω	5%	1/2 W	Comp	312600
R126	20 Ω	5%	1/2 W	Comp	312600
R127	1.5 k Ω	5%	1/2 W	Comp	313040
R128	1 M Ω	5%	1/2 W	Comp	313650
R129	2 k Ω	5%	1/2 W	Comp	313070
R130	1 k Ω	5%	1/2 W	Comp	313000
R131	1 k Ω	5%	1/2 W	Comp	313000
R132	2 k Ω	5%	1/2 W	Comp	313070
R133	10 k Ω	1%	1/4 W	MF	316350
R134	5.11 k Ω	1%	1/4 W	MF	316230
R135	4.46 kΩ	1%	1/4 W	MF	316230
R136	1 k Ω		Cer	Var	322044
R137	20 k Ω		Cer	Var	322047
R138	2 k Ω		Cer	Var	322045
R139	2.37 k Ω	1%	1/4 W	MF	316171
R140	200 Ω	1%	1/4 W	MF	315840
R141	10 k Ω	5%	1/2 W	Comp	313240
R142	100 k Ω	1%	1/4 W	MF	313490
R143	24.9 k Ω	1%	1/4 W	MF	316515
R144	24.9 k Ω	1%	1/4 W	MF	316515
R145	100 k Ω	1%	1/4 W	MF	316620
R146	130 k Ω	5%	1/2 W	Comp	313510
R147	270 k Ω	5%	1/2 W	Comp	313580
R148	10 k Ω	1%	1/4 W	MF	316350
R149	10 k Ω	5%	1/2 W	Comp	313240
R150	124 k Ω	1%	1/8 W	MF	315128
R151	124 k Ω	1%	1/8 W	MF	315128
R152	124 k Ω	1%	1/8 W	MF	315128
R153	124 k Ω	1%	1/8 W	MF	315128
R154	124 k Ω	1%	1/8 W	MF	315128
R155	124 k Ω	1%	1/8 W	MF	315128
R156	124 k Ω	1%	1/8 W	MF	315128
R157	124 k Ω	1%	1/8 W	MF	315128
R158	124 k Ω	1%	1/8 W	MF	315128
R159	124 k Ω	1%	1/8 W	MF	315128

Schematic Ref	Value	Specifications			F.W. Bell Item No.
R160	124 k Ω	1%	1/8 W	MF	315128
R161	124 k Ω	1%	1/8 W	MF	315128
R162	124 k Ω	1%	1/8 W	MF	315128
R163	61.9 k Ω	1%	1/8 W	MF	315140
R164	61.9 k Ω	1%	1/8 W	MF	315140
R165	61.9 k Ω	1%	1/8 W	MF	315140
R166	61.9 k Ω	1%	1/8 W	MF	315140
R167	61.9 k Ω	1%	1/8 W	MF	315140
R168	61.9 k Ω	1%	1/8 W	MF	315140
R169	61.9 k Ω	1%	1/8 W	MF	315140
R170	61.9 k Ω	1%	1/8 W	MF	315140
R171	61.9 k Ω	1%	1/8 W	MF	315140
R172	61.9 k Ω	1%	1/8 W	MF	315140
R173	61.9 k Ω	1%	1/8 W	MF	315140
R174	8.2Ω	5%	2 W	WW	319930
R175	7.5Ω	5%	2 W	WW	319920
R176	3.3 Ω	5%	2 W	WW	319845
R177	620 Ω	5%	1/2 W	Comp	312950
R178	100 Ω	5%	1/2 W	Comp	312770
R179	100 k Ω	5%	1/2 W	Comp	313490
R180	100 k Ω	5%	1/2 W	Comp	313490
R181	100 k Ω	5%	1/2 W	Comp	313490
R182	10 k Ω	5%	1/2 W	Comp	313240
R183	10 k Ω	5%	1/2 W	Comp	313240
R184	10 k Ω	5%	1/2 W	Comp	313240
R185	100 k Ω	5%	1/2 W	Comp	313490
R186	100 k Ω	5%	1/2 W	Comp	313490
R187	100 k Ω	5%	1/2 W	Comp	313490
R188	10 k Ω	5%	1/2 W	Comp	313240
R189	10 k Ω	5%	1/2 W	Comp	313240
R190	10 k Ω	5%	1/2 W	Comp	313240
R191	1 k Ω	5%	1/2 W	Comp	313000
R192	100 k Ω	5%	1/2 W	Comp	313490
R193	100 k Ω	5%	1/2 W	Comp	313490
R194	100 k Ω	5%	1/2 W	Comp	313490
R195	FOP	5%	1/2 W	Comp	FOP
R196	680 Ω	5%	1/2 W	Comp	312960
R197	47 k Ω	5%	1/2 W	Comp	313400
R198	24 k Ω	5%	1/2 W	Comp	313330
R199	47 k Ω	5%	1/2 W	Comp	313400
R101A	3.3 Ω	5%	2 W	WW	319845
R102A	10 Ω	5%	1/2 W	Comp	312570
R103A	10 Ω	5%	1/2 W	Comp	312570
R104A	22 M Ω	5%	1/2 W	Comp	313670
R105A	470 k Ω	5%	1/2 W	Comp	313610
R106A	10 M Ω	5%	1/2 W	Comp	313680
R107A	240 Ω	5%	1/2 W	Comp	312850
R1	20 k Ω	10 turn		Var	321680
R2	250 k Ω			Var	321245
R3	5Ω			Var	320965
C101	2.2 μf @ 35 V			Tan	325680
C102	0.1 μf @ 20 V			Cer	325230
C103	0.0047 μf @ 200 V			Myl	324450
C104	180 pf @ 1000 V			Cer	325400
C105	0.1 μf @ 20 V			Cer	325230
C106	0.1 μf @ 20 V			Cer	325230
C107	0.1 μf @ 20 V			Cer	325230
C108	0.0033 μf @ 200 V			Myl	324430
C109	1 μf @ 35 V			Tan	325670
C110	0.001 μf @ 1000 V			Cer	325510

Schematic Ref	Value		Specifications	F.W. Bell Item No.
C111	56 pf @ 1000 V		Cer	325330
C112	330 pf @ 1000 V		Cer	325479
C113	10 μf @ 16 V		Elect	323310
C114	10 μf @ 16 V		Elect	323310
C115	4700 μf @ 10 V		Elect	323030
C116	350 μf @ 16 V		Elect	323380
C117	350 μf @ 16 V		Elect	323380
C118	350 μf @ 16 V		Elect	323380
C119	5 μf (2-10 μf Caps)	NP	Elect	323310
C120	1 μf @ 35 V		Tan	325670
C121	.0047μf		Myl	324450
C122	.01 μf @ 200 V		Myl	325520
C123	56 pf @ 1000 V		Cer	325330
C124	10 pf @ 1000 V		Cer	325250
C125	.001 μf @ 1000 V		Cer	325510
C126	10 pf @ 1000 V		Cer	325250
C127	10 μpf @ 1000 V		Cer	325250
C128	.001 μf @ 1000 V		Cer	325510
C129	100 pf @ 1000 V		Cer	325380
C130	0.1 μf @ 20 V		Cer	325230
C131	.0047 μf @ 200 V		Myl	324450
CR101	1N914		Diode	328015
CR102	1N456		Diode	328000
CR103	1N5231A (5.1V)		Zener	328450
CR104	1N5231A (5.1V)		Zener	328450
CR105	1N4003		Diode	328090
CR106	1N4003		Diode	328090
CR107	1N4003		Diode	328090
CR108	1N4003		Diode	328090
CR109	1N4003		Diode	328090
CR110	1N4003		Diode	328090
CR111	1N914		Diode	328015
CR112	1N914		Diode	328015
CR113	1N914		Diode	328015
CR114	1N914		Diode	328015
CR115	1N914		Diode	328015
CR116	1N914		Diode	328015
CR117	1N5343B (7.5 V)		Zener	328481
CR118	1N5343B (7.5 V)		Zener	328481
CR120	1N5231A (5.1 V)		Zener	328450
Q101	2N3903		Transistor	329030
Q102	2N3903		Transistor	329030
Q103	2N3903		Transistor	329030
Q104	T1573		FET	329290
Q105	2N5190		Transistor	329190
Q106	2N5190		Transistor	329190
Q107	2N3905		Transistor	329040
Q108	2N3903		Transistor	329030
Q109	2N3905		Transistor	329040
Q110	2N3903		Transistor	329030
Q111	2N3905		Transistor	329040
Q112	2N3903		Transistor	329030
Q113	2N5190		Transistor	329190
Q114	2N5193		Transistor	329200
IC101	741		Op Amp	329985
IC102	741		Op Amp	329985
IC103	741		Op Amp	329985
IC104	7805		Reg	329984
IC105	4001 (CMOS)		Quad Nor	330074
IC106	709		Op Amp	329950

Schematic Ref	Value	Specifications		F.W. Bell Item No.
IC107	CA 3130		Op Amp	330076
IC108	311		Comparator	329983
IC109	741		Op Amp	329985
IC110	4040 (CMOS)	12 Stage Ripple Counter		330073
IC111	4011		Quad Nand	330072
IC112	78MO8		Reg	329986
IC113	79MO8		Reg	329987
IC114	4001 (CMOS)		Quad Nor	330074
IC115	4016 (CMOS)		Quad T G	330075
IC116	741		Op Amp	329985
IC117	741		Op Amp	329985
IC118	4001		Quad Nor	330074
L101	Coil/Core		Inductor	326185/344379
T101	LA-1994		Transformer	326035
T102	LB-1993/Core		Transformer	326187/344457
I101	#63		Lamp	330481
S101	6 Pole 5 Station		Switch	334399
F101	1/8 A-110 V (SB)		Fuse	330700
	1/16A-220 V (SB)		Fuse	330680
B1	5 volt		Battery Pkg.	335630
J1			Amp Connector	331723
		For use in J1 (9) Pins		331351
J2			Connector, Power	★
P1			Cord, Power	★★

★ *331280 Used on Serial #192246 and Below*
331282 Used on Serial #192247 and Above

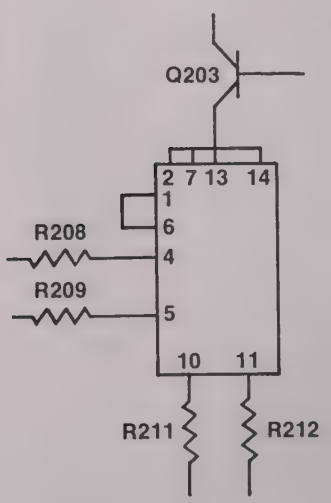
★★ *334770 Used on Serial #192246 and Below*
334800 Used on Serial #192247 and Above

3-1/2 DIGIT PANEL METER

Schematic Ref	Value	Specifications			F.W. Bell Item No.
R201	3.01 kΩ	1%	1/8W	MF	315150
R202	5.0 kΩ	1%	1/8W	MF	315160
R203	2 kΩ		CER	VAR	322045
R204	10 kΩ	5%	1/4W	Comp	312280
R205	470 kΩ	5%	1/4W	Comp	312339
R206	300 kΩ	5%	1/4W	Comp	312335
R207	10 kΩ	5%	1/4W	Comp	312280
R208	150 Ω	5%	1/4W	Comp	312087
R209	4.7 Ω	5%	1/4W	Comp	312080
R210	10 kΩ	5%	1/4W	Comp	312280
R211	68 Ω	5%	1/4W	Comp	312085
R212	68 Ω	5%	1/4W	Comp	312085
R213	150 Ω	5%	1/4W	Comp	312087
R214	150 Ω	5%	1/4W	Comp	312087
R215	150 Ω	5%	1/4W	Comp	312087
R216	10 kΩ	5%	1/4W	Comp	312280
R217	49.9 kΩ	1%	1/8W	MF	315127
R218	24.9 kΩ	1%	1/8W	MF	315126
R219	24.9 kΩ	1%	1/8W	MF	315126
R220	49.9 kΩ	1%	1/8W	MF	315127
R221	49.9 kΩ	1%	1/8W	MF	315127
R222	24.9 kΩ	1%	1/8W	MF	315126
R224	10 kΩ	1%	1/8W	MF	315121
R225	49.9 kΩ	1%	1/8W	MF	315127
R226	10 kΩ		CER	VAR	322048

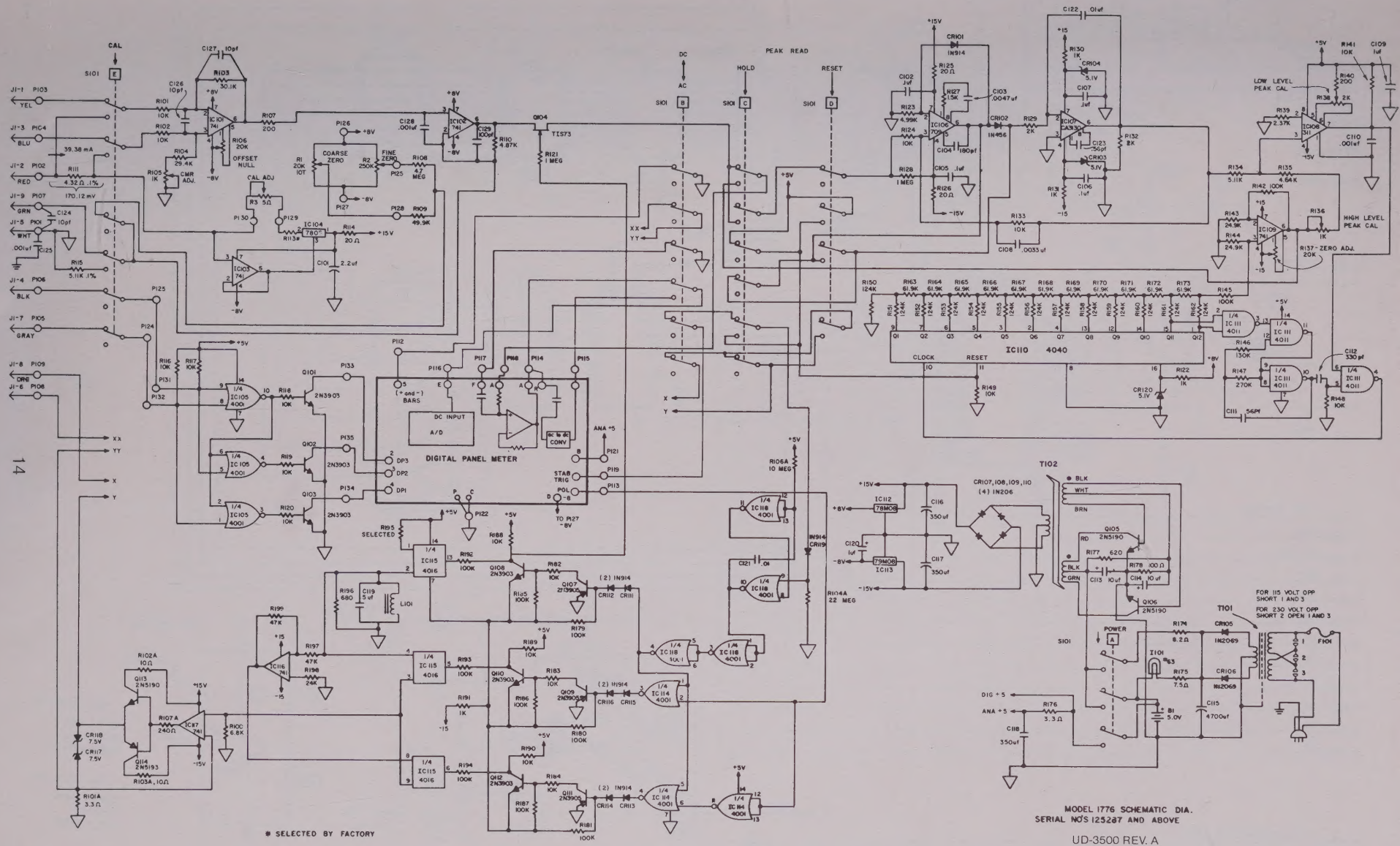
Schematic Ref	Value	Specifications			F.W. Bell Item No.
			CER	VAR	
R227	20 kΩ				322047
R228	10 kΩ	1%	1/8 W	MF	315121
R229	1.78 kΩ	1%	1/8 W	MF	315091
R230	10 kΩ	5%	1/4 W	Comp	312280
R231	10 kΩ	5%	1/8 W	Comp	312280
RN201	10 kΩ	7-Resistor Network			322705
RN202	150 Ω	7-Resistor Network			322660
C201	.68 μf	TAN			325690
C202	.68 μf	TAN			325690
C203	10 μf @ 16 V	Elect			323310
C204	10 μf @ 16 V	Elect			323310
C205	.1 μf @ 400 V	Myl			325171
C206	.1 μf @ 400 V	Myl			325171
C207	33 μf @ 16 V	NP Elect			323390
C208	3.3 μf	Elect			323035
CR201	1N914	Diode			328015
CR202	1N914	Diode			328015
Q201	2N3903	Transistor			329030
Q202	2N3903	Transistor			329030
Q203	2N3904	Transistor			329035
Q204	2N3903	Transistor			329030
Q205	2N3903	Transistor			329030
Q206	2N3903	Transistor			329030
Q207	2N3903	Transistor			329030
Q208	2N3905	Transistor			329040
IC-201	741	OP AMP			329985
IC-202	MC-1403	2.5 V REF			329989
IC-203	MC-14433	A/D			330077
IC-204	MC-14558	7 Seg. Decode/Driver			330070
IC-205	CD-3081	Transistor Array			329981
IC-206	741	OP AMP			329985
IC-207	741	OP AMP			329985
IC-208	CD-4011	Quad Nand Gate			330072
LED-201	hp5082-7650	7 Seg. LED			330520
LED-202	hp5082-7650	7 Seg. LED			330520
LED-203	hp5082-7650	7 Seg. LED			330520
LED-204	hp5082-765	+1 overflow			330530***
LED-205	5077B	LED			329475

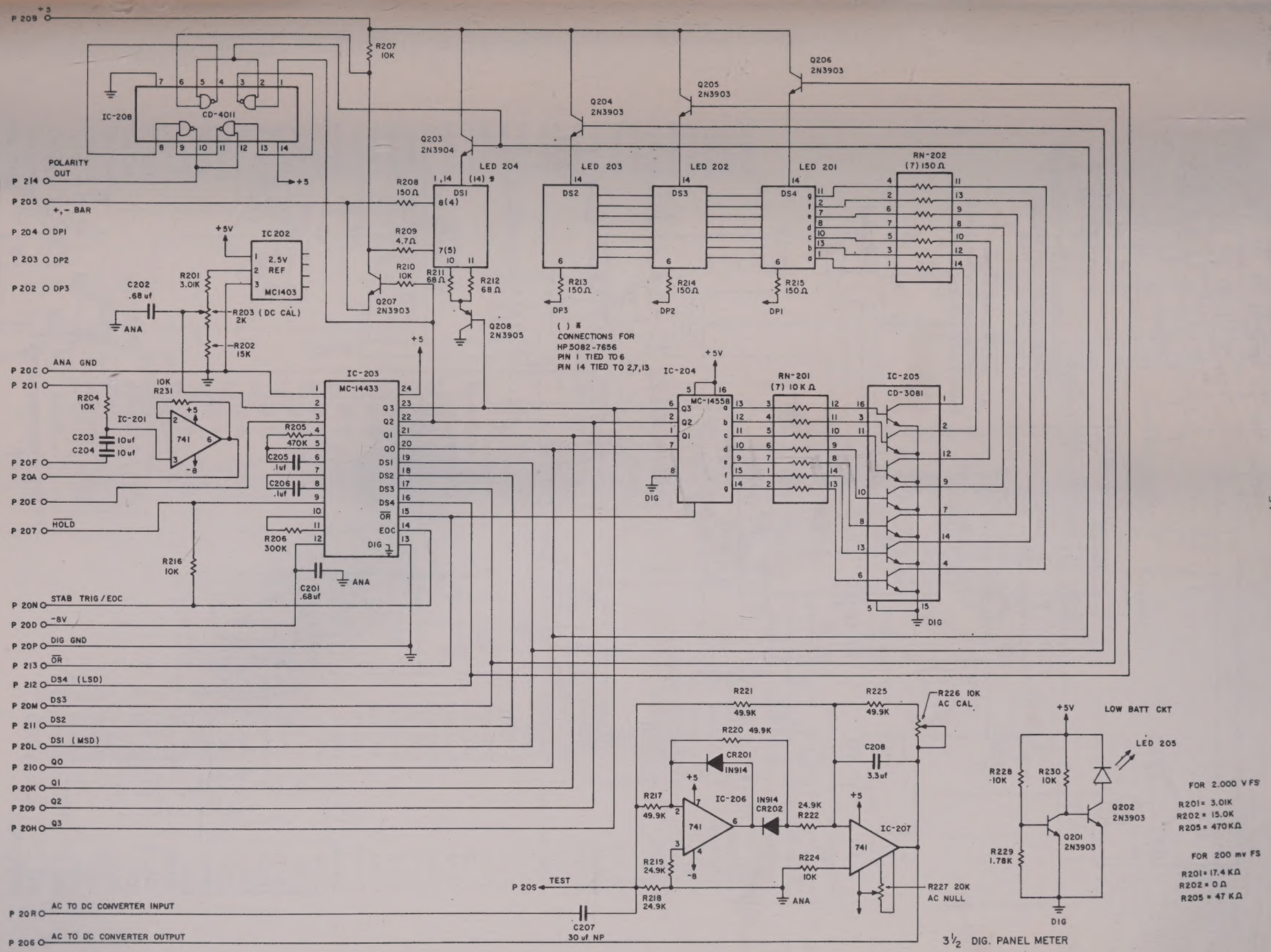
***330530 used in Serial #207667 and below
330535 used on Serial #207668 and above



Note: This connection applies only with serial numbers 207668 and above.

Connections for DSI HDSP 5082-7656 (30535) Refer UD-3316 REV. B. (Page 15)


DIGITAL PANEL METER
DC INPUT
A/D
DC to dc CONV
(+ and -) BARS
IC110 4040
CLOCK
RESET
PEAK READ
HOLD
RESET
LOW LEVEL PEAK CAL
HIGH LEVEL PEAK CAL
R137 - ZERO ADJ.
OFFSET NULL
CMR ADJ.
CAL ADJ
COARSE ZERO
FINE ZERO
SELECTED
CR107, 108, 109, 110 (4) IN206
FOR 115 VOLT OPP SHORT 1 AND 3
FOR 230 VOLT OPP SHORT 2 OPEN 1 AND 3
* SELECTED BY FACTORY
MODEL 1776 SCHEMATIC DIA.
SERIAL NO'S 125287 AND ABOVE
UD-3500 REV. A



$3\frac{1}{2}$ DIG. PANEL METER

DWG NO. UD-3316 REV B

WARRANTY

F.W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof (excluding batteries). This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F.W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F.W. BELL, INC., and F.W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F.W. BELL, INC. instruments.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

Use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two or three inches of shock-absorbing material.

Ship to:

F.W. BELL, INC.
Repair Department
6120 Hanging Moss Road
Orlando, FL 32807
Phone: 407-678-6900
TWX: 810-853-3115
Fax: 407-677-5765

www.manualsplus.com
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